

## CHAPTER 2.0: HYDROLOGIC FRAMEWORK

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Prepared by:

Ed Salminen (primary author)

Chuck Lindsay (contributed to geology)

Karen Kuzis (basin history)

## **GLOSSARY**

**Alluvium:** Sediments deposited by erosional processes, usually by streams.

**DEM:** See Digital Elevation Model.

**Digital Elevation Model:** Digital representation of the earth's surface. Elevations are given in a grid format. Usually referred to by the spacing of the grid (e.g., a "10-meter" digital elevation model (DEM) has elevation values at a 10 x 10 meter spacing).

**El Niño/Southern Oscillation:** A climatic variability pattern common in the Pacific Northwest. Similar to the Pacific Decadal Oscillation (PDO), except that El Niño/Southern Oscillation (or ENSO) events typically persist for only 6 to 18 months while Pacific Decadal Oscillation (or PDO) events typically persist for 20-to-30 year periods.

**ENSO:** See El Niño/Southern Oscillation.

**FERC:** Federal Energy Regulatory Commission. An independent regulatory agency within the Department of Energy that, among other things, licenses and inspects private, municipal, and state hydroelectric projects.

**Glacial drift:** Sediment deposited directly by glaciers or indirectly by meltwater in streams, in lakes, and in the sea. Also called drift.

**HSG:** See hydrologic soil group.

**Hydrologic regime:** The timing, magnitude, duration, and spatial distribution of peak, high, and low flows. Hydrologic regimes common in Washington include rain-, rain-on-snow, and/or snowmelt-dominated runoff patterns.

**Hydrologic soil groups:** Soils grouped by characteristics that affect the rates of water infiltration and transmission (rate at which the water moves within the soil).

**Infiltration:** To permeate something by penetrating its pores or interstices.

**Lahars:** A mudflow composed of volcanic debris and water.

**Mean:** Synonymous with the average.

**NCDC National Climatic Data Center (NCDC):** A division of the National Oceanic and Atmospheric Administration (NOAA). NCDC archives and distributes NOAA climatic data.

**Pacific Decadal Oscillation:** A climatic variability pattern common in the Pacific Northwest. Similar to the El Niño/Southern Oscillation (ENSO), except that Pacific Decadal Oscillation (or PDO) events typically persist for 20-to-30 year periods, while ENSO events typically persist for 6 to 18 months.

**PDO:** See Pacific Decadal Oscillation.

**Pleistocene Epoch:** The period of geologic time referred to as the "Ice Age". This period occurred 2 million to 10,000 years before present.

**Spatial:** Relating to, occupying, or having the character of space.

**Stade:** A short period of time (less than 10,000 years) characterized by climatic conditions associated with maximum glacial extent.

**Standard deviation:** A measure of the spread or dispersion of a set of data. It is calculated by taking the square root of the variance (a non-negative number which gives an idea of how widely spread the values of a variable are likely to be; the larger the variance, the more scattered the observations on average). The more widely the values are spread out, the larger the standard deviation.

**Surficial geology:** Surface or near surface geology.

**Temporal:** Of or relating to time as distinguished from space; of or relating to the sequence of time or to a particular time.

**Transmission:** Rate at which the water moves within the soil.

**WAU:** Watershed Administrative Unit. Administrative and planning units that encompass smaller areas within WRIAs. There are 828 WAUs within the state of Washington.

**WDNR:** Washington Department of Natural Resources.

**WRIA:** Water Resource Inventory Area. Administrative and planning units that encompass large river basins. There are 62 WRIAs within the state of Washington.

## **CHAPTER 2.0: HYDROLOGIC FRAMEWORK**

### **INTRODUCTION**

Several characteristics of the watershed affect local hydrologic conditions. The most significant of these factors are topography, soils, geology, climate, precipitation, land use, and dams. These factors are summarized below for the subbasins within the Nisqually watershed.

### **BASIN HISTORY**

The history of the watershed includes a number of activities potentially affecting fish habitat and water quality. Habitat impacts are primarily related to road, railroad, and hydroelectric development. Surface and groundwater withdrawals for irrigation and domestic use reduce flows during upstream migration and spawning periods for salmon. The diversion of the upper Ohop Creek into the Puyallup watershed (Hlavin, 1954) resulted in impacts to fish habitat and reduction in stream flow (loss of roughly 30% of watershed area).

Table 2-1. Timeline of Historic Events potentially impacting aquatic habitat (Kerwin 1999).

<b>DATE</b>	<b>EVENT</b>
	One of first areas settled in Puget Sound by Euro-American immigrants
1792	First European description of Nisqually River mouth
1833	Fort Nisqually, fur trading post, est. by Hudson Bay Co.
1845	European Settlers in vicinity of McAllister Creek – begin clearing and farming
1850	Donation Land Claim – encourages more settlement
1852	1 <sup>st</sup> Ferry crossing Nisqually River
1853	Railroad surveys conducted
1854	Medicine Creek Treaty Signed Large tracts of land given up by Nisqually Tribe
1858	Wetland draining begins
1870	Irrigation of agricultural lands begin
1889	Upper Ohop Creek diverted into Puyallup River (loss of ~30% of watershed area)
1899	Mt. Rainer National Park Established – headwaters protected
1904	First dikes constructed on River Delta
1910	La Grande Hydroelectric Project constructed – no significant flow impacts
1912	North Pacific Railway constructs Point Defiance line
1929	Yelm Hydroelectric Project Constructed – no fish ladder, no screens, diverted much of the flow.

DATE	EVENT
1942-44	Reconstruction of Alder/LaGrande Hydroelectric Complex - major flow Impacts
1940's-1970's	Major logging activities in upper watersheds
1965	Port of Tacoma annexation of 110 acres of Nisqually Delta for deepwater port
1971	US Dept. of Interior designates 2756 acres of Nisqually Delta as a Natural Landmark
1974	Brown Farm purchased by Dept. of Interior and designated a National Wildlife Refuge
1977	Copper Ore Spill – Nisqually River RM 21
1978	Minimum Flows ordered by FERC
1999	Puget Sound Chinook Listed as Threatened

## **TOPOGRAPHY**

One of the most basic parameters affecting watershed hydrology is basin topography. The elevation range found within a watershed, or subbasin, largely determine the hydrologic regime (i.e., rain-, rain-on-snow, or snowmelt-dominated runoff patterns) of the area. Similarly, basin relief determines the potential energy available to move water through the system.

The surface topography in the study area is generally the result of erosion and deposition during and since the last glaciation of the area, approximately 15,000 years ago (Dion, et al, 1994). The physiography of the area is widely varied ranging from temperate lowlands near sea level to high mountainous terrain at elevations over 5,000 feet. With the exception of the portions of the Tanwax/Kreger/Ohop and Mashel subbasins, most of study area is located below elevation 1,000 feet and is a dissected low-lying glacial drift plain. The drift plains have numerous local closed depressions, many of which are occupied by lakes and wetlands, particularly near Lake St. Clair (McAllister subbasin).

Mean subbasin elevation generally increases moving upstream through the basin (Table 2-2). All of the subbasins in the assessment area have a mean elevation below 1,000 feet, with the exception of the Tanwax/Kreger/Ohop and Mashel subbasins. The portions of the Tanwax/Kreger/Ohop subbasin that drain Twentyfive Mile and Lynch Creeks, and the entire Mashel subbasin, differ from the other subbasins in that they are located in the Cascade foothills. Mean subbasin slope also generally increases moving upstream through the basin, with some exceptions. The McAllister subbasin has a steeper mean basin slope than either the Muck/Murray or Yelm subbasins. This is probably due to the steep bluffs along the Nisqually valley, which make up a relatively large area of the McAllister subbasin.



Table 2-2. Subbasin elevations and slopes. Data Source: USGS (2001) - 10-meter DEM data.

Subbasin	Elevation (ft)			Mean slope
	Mean	Min	Max	
1. McAllister	244	0	640	9%
2. Muck/Murray	446	0	928	5%
3. Yelm	410	100	640	6%
4. Toboton/Powell/Lackamas	808	340	2,035	19%
5. Tanwax/Kreger/Ohop	1,060	360	3,720	16%
6. Mashel	2,237	460	4,845	31%
<i>Lower basin (subbasins 1 – 6) subtotal</i>	892	0	4,845	13%
7. Upper Basin	2,987	600	14,410	55%
Entire WRIA	1,686	0	14,410	29%

The Muck/Murray and Yelm subbasins are the “flattest” subbasins in the analysis area. Slightly less than 50 percent of the area in both subbasins has slopes less than 3 percent, and approximately 2% of the area has slopes greater than 30 percent (Figure 2-1). Conversely, the Mashel subbasin is the “steepest” subbasin in the lower watershed. Over 40% of the subbasin area has slopes greater than 30%.

In summary, with the exception of the Mashel subbasin, the subbasins found in the lower watershed are low-elevation and of low relief. All subbasins in the lower watershed have a rain-dominated hydrologic regime, except for the Mashel subbasin, which has a rain-on-snow dominated hydrologic regime. Similarly, the low relief of all subbasins with the exception of the Mashel, limit the potential energy available to move water through the system, resulting in relatively low stream velocities and erosion potential. The data needed to describe the topography of the subbasins (i.e., digital elevation model data) is readily available and of adequate resolution to be used if any level II modeling of basin hydrology is required.

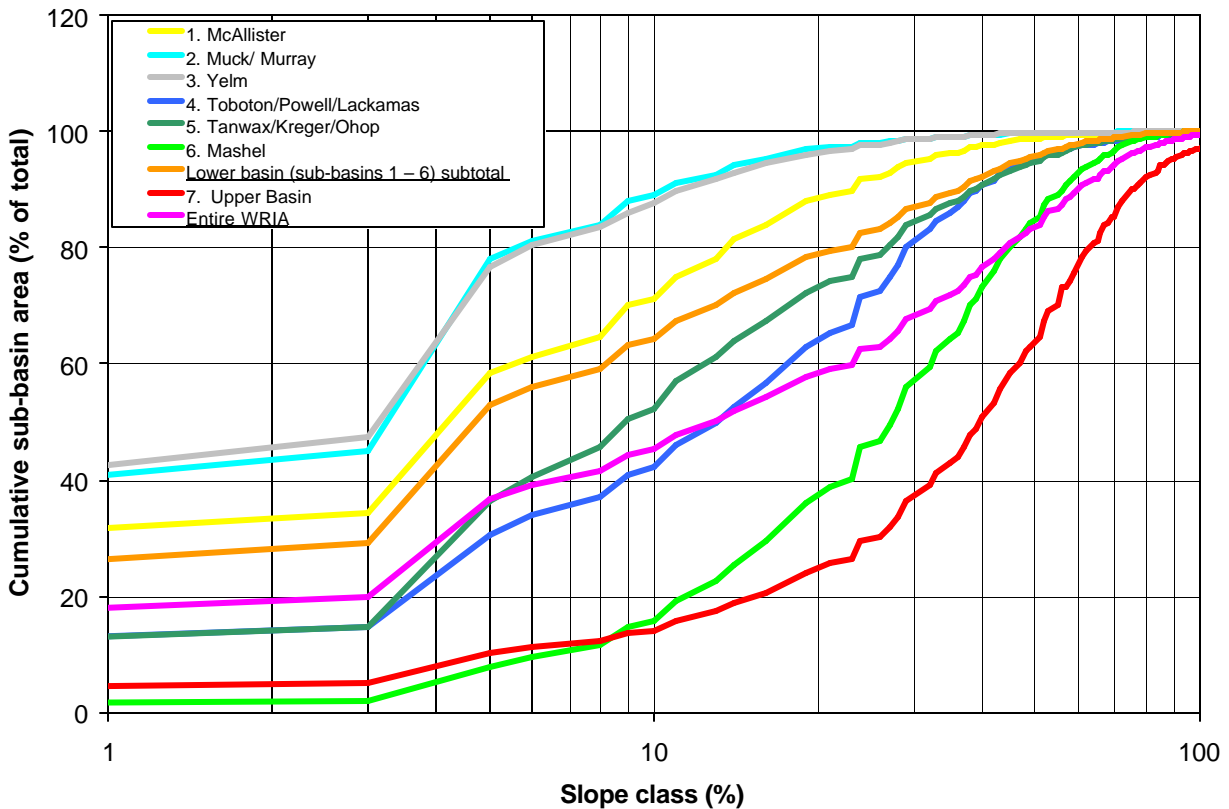


Figure 2-1. Cumulative subbasin area by slope class. Data Source: USGS (2001) - 10-meter DEM data.

## SOILS

The properties of soils found within a watershed, or subbasin, influence to a large extent the movement of water through and within the soil layers. Information on soils in the lower Nisqually Basin is available from three separate soil surveys produced by the USDA Natural Resources Conservation Service (Formerly Soil Conservation Service). The Thurston County portion of the basin is covered in the Soil survey of Thurston County, Washington (NRCS, 1990), and the Pierce County Portion is covered in the Soil Survey of Pierce County Area (NRCS, 1979) and Soil Survey of Snoqualmie Pass Area, Parts of King and Pierce Counties (NRCS, 1992) (Figure 2-2).

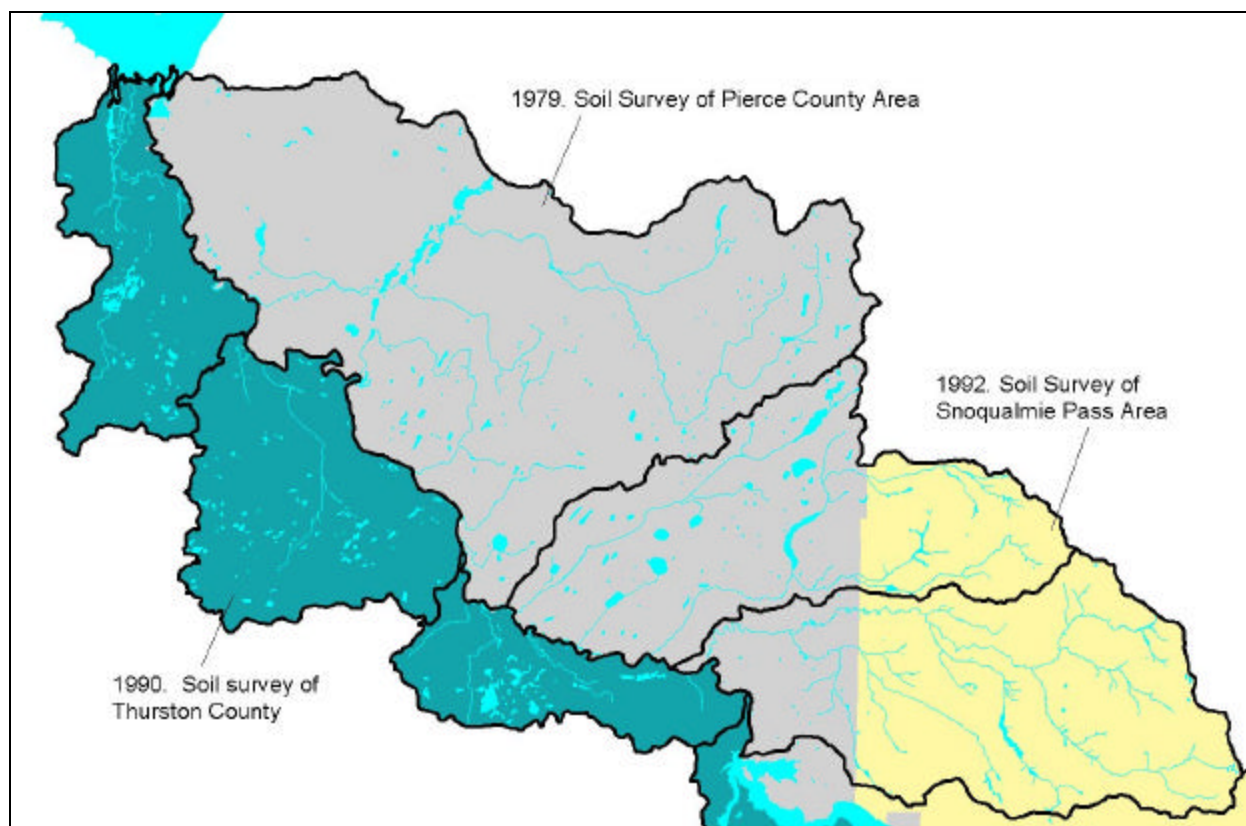


Figure 2-2. Soil surveys covering the lower Nisqually Basin. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage), fish-bearing streams, and water bodies; Thurston County GeoData Center (2001), Pierce County GIS Department (2001), and NRCS (2001) - Soil Survey coverage area.

The NRCS has classified soils into hydrologic soil groups (HSGs) to indicate the rates of infiltration and transmission (rate at which the water moves within the soil) (NRCS, 1986) (Table 2-3). Unfortunately, HSG information is only available in digital format for the areas covered by the Soil survey of Thurston County and the Soil Survey of the Snoqualmie Pass Area (Figures 2-2 and 2-3). Information on the HSG is available for the soil types found in the remainder of the area, but the individual soil polygons are available on hardcopy maps only, not in digital format. Hence, information on soil infiltration rates is readily available<sup>1</sup> in digital format for only 55 percent of the lower Nisqually watershed.

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<sup>1</sup> It is not possible, given the level of effort expected for the level I assessment, to summarize the soil information that is only available in hardcopy format

Table 2-3. Descriptions of hydrologic soil group properties (NRCS, 1986).

Group	Typical soil textures	Infiltration/Transmission Properties
A	Deep, well drained to excessively drained gravel, sand, loamy sand, or sandy loam	High infiltration rates. High rate of water transmission (greater than 0.30 in/hr).
B	Deep to moderately deep, moderately well to well drained soils with moderately fine to moderately coarse textures (silt loam or loam)	Moderate infiltration rates. Moderate rate of water transmission (0.15-0.30 in/hr).
C	Soils with layers impeding downward movement of water, or soils with moderately fine or fine textures (sandy clay loam)	Slow infiltration rates. Low rate of water transmission (0.05-0.15 in/hr).
D	Soils are clayey, have a high water table, or are shallow to an impervious layer (clay loam, silty clay loam, sandy clay, silty clay, or clay)	Very slow infiltration rates. Very low rate of water transmission (0-0.05 in/hr).

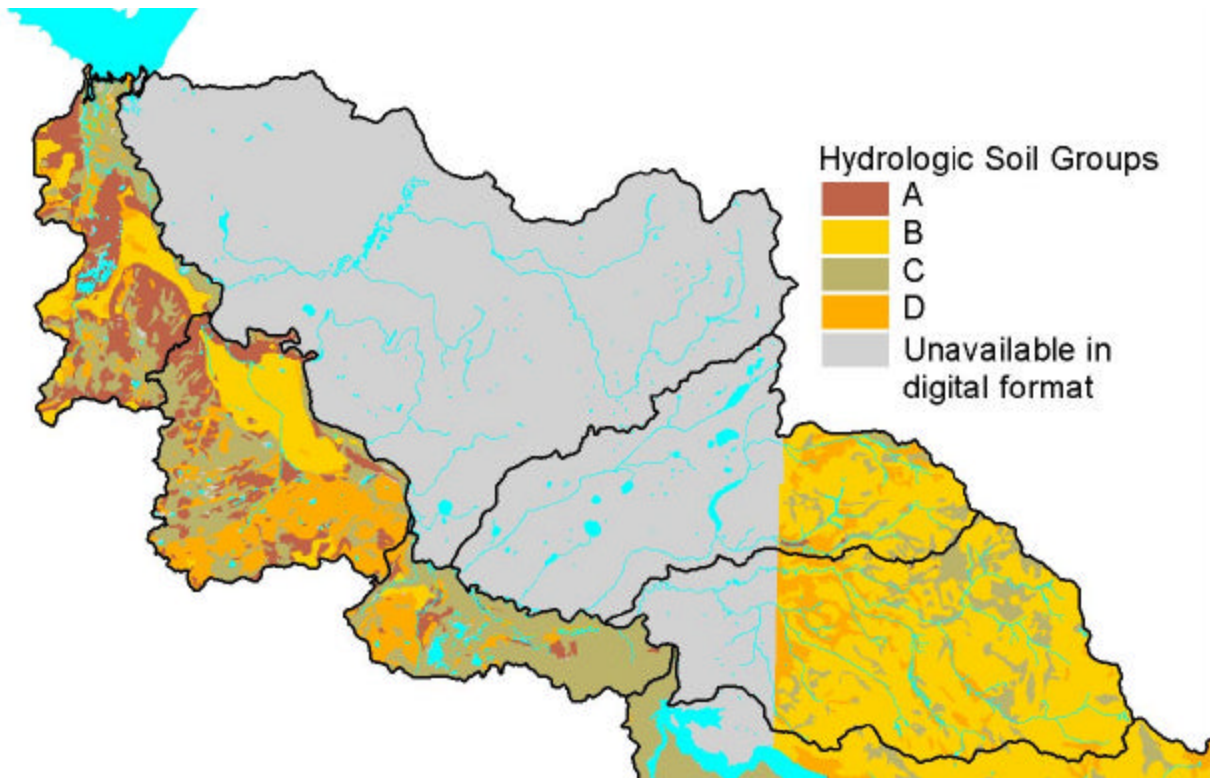


Figure 2-3. Hydrologic soil groups found in the lower Nisqually Basin. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage), fish-bearing streams, and water bodies; Thurston County GeoData Center (2001), Pierce County GIS Department (2001), and NRCS (2001) - Hydrologic Soil Groups.

Soils in the McAllister subbasin have the highest infiltration and transmission rates found in the lower Nisqually Basin (Table 2-4). Approximately 40% of the soils fall in HSG A and 20% fall in HSG B. There is no digital information for the Muck/Murray subbasin, however, given that the Muck/Murray subbasin is roughly similar in geology to the Yelm subbasin, it would be reasonable to assume that the HSG properties are similar to the Yelm subbasin which has approximately 40% of its area in HSGs A and B. Over 90% of the area in the Toboton/Powell/Lackamas subbasin has slow to very slow infiltration rates. Digital HSG information is unavailable for 72% of the Tanwax/Kreger/Ohop subbasin, and the area for which digital data is available is probably not representative of the entire subbasin due to differences in the underlying geology. Overall the Tanwax/Kreger/Ohop subbasin is probably similar to the Toboton/Powell/Lackamas subbasin in terms of HSG properties. Digital HSG information is unavailable for 21% of the Mashel subbasin; however, the area for which digital data is available is probably representative of the entire subbasin. The Mashel subbasin has approximately half its area in HSGs A and B, and half in HSGs C and D.

Table 2-4. Summary of percent subbasin area by Hydrologic Soil Group. Values given as “% 0” indicate less than 0.5% of the subbasin area is in this type.

Subbasin name	A	B	C	D	Unavailable
1. McAllister	39%	18%	30%	12%	-
2. Muck/Murray	-	-	-	-	100%
3. Yelm	19%	20%	31%	30%	-
4. Toboton/Powell/Lackamas	5%	2%	74%	18%	-
5. Tanwax/Kreger/Ohop	0%	19%	4%	5%	72%
6. Mashel	0%	57%	11%	11%	21%
<b>Lower Basins (subbasins 1-6) total</b>	<b>6%</b>	<b>18%</b>	<b>13%</b>	<b>8%</b>	<b>55%</b>

In summary, soil infiltration and transmission rates generally decrease moving upstream among the subbasins in the lower Nisqually Basin, with the exception of the Mashel subbasin, which has higher rates than the adjacent Toboton/Powell/Lackamas and Tanwax/Kreger/Ohop subbasins. Information on HSG characteristics is directly applicable in this level I analysis in choosing representative stream gages to characterize stream flows in the subbasins (Chapter 5.1). In addition, this information would be necessary if any level II modeling of basin hydrology is required. As such, the lack of digital soils information for the area covered by the Pierce County soil survey (NRCS, 1979) will be advanced as a data gap.

## **GEOLOGY**

The underlying geology of a watershed, or subbasin, influences to a large extent the movement of ground water in the area. Information on surficial geology in the lower Nisqually Basin is available from Walsh, et al (1999).

Continental glaciers advanced into Pierce and Thurston Counties several times during the Pleistocene Epoch. The most recent glaciation, the Vashon Stade of the Fraser Glaciation, began about 15,000 years ago when the climate cooled and a continental ice mass formed in British Columbia, Canada. The result of these repeated glacial advances and retreats is that most of the western portion of WRIA 11 is covered by as much as 2,000 feet of unconsolidated glacial and non-glacial deposits overlying bedrock (Drost et al, 1999) (Figures 2-4 and 2-5, Table 2-5). Alluvium (modern river deposits) is also found along the major rivers in the western portion of the WRIA. These deposits vary in size from sand to cobbles and boulders. All of these deposits tend to be unconsolidated. As a result, water percolates easily through these materials.

Unlike the western portion, large areas of the eastern portion of WRIA 11, primarily the Upper Basin, Mashel, Toboton/Powell/Lackamas, and Tanwax/Kreger/Ohop subbasins, were not covered by continental glacial ice. The surface geology in these areas generally consists of sedimentary and volcanic formations (bedrock) (Figures 2-4 and 2-5, Table 2-5).

Information on surficial geology is directly applicable in this level I analysis in choosing representative stream gages to characterize stream flows in the subbasins (Chapter 5.1), and in the analysis of groundwater (Chapter 5.2). In addition, this information would be necessary if any level II modeling of basin hydrology is required. The data needed to describe the surficial geology of the subbasins (i.e., Walsh et al, 1999) is readily available and of adequate resolution to be used if any level II modeling of basin hydrology is required.

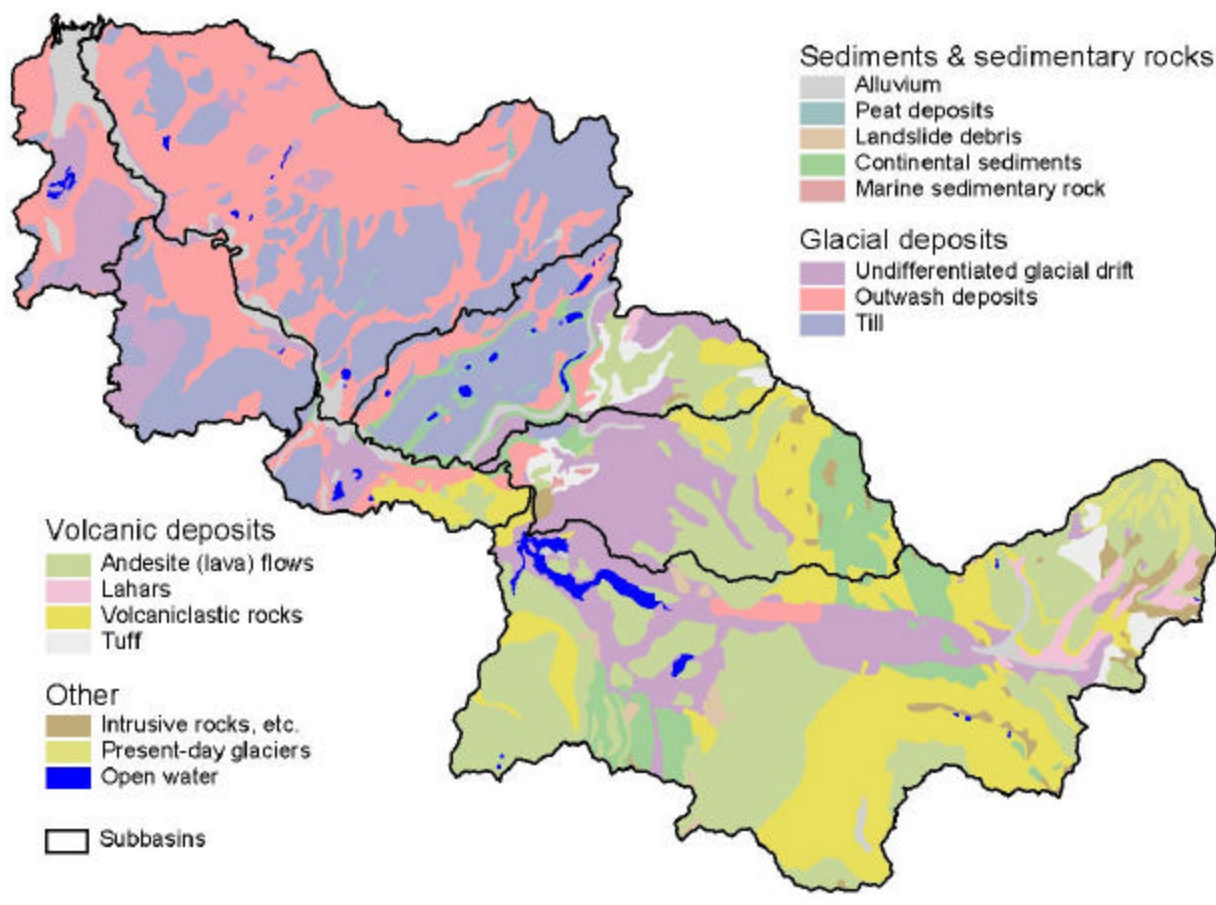


Figure 2-4. Surficial geology of the Nisqually Basin. Descriptions of map symbols are given in Table 2-5. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage); Walsh et al (1999) - surficial geology.

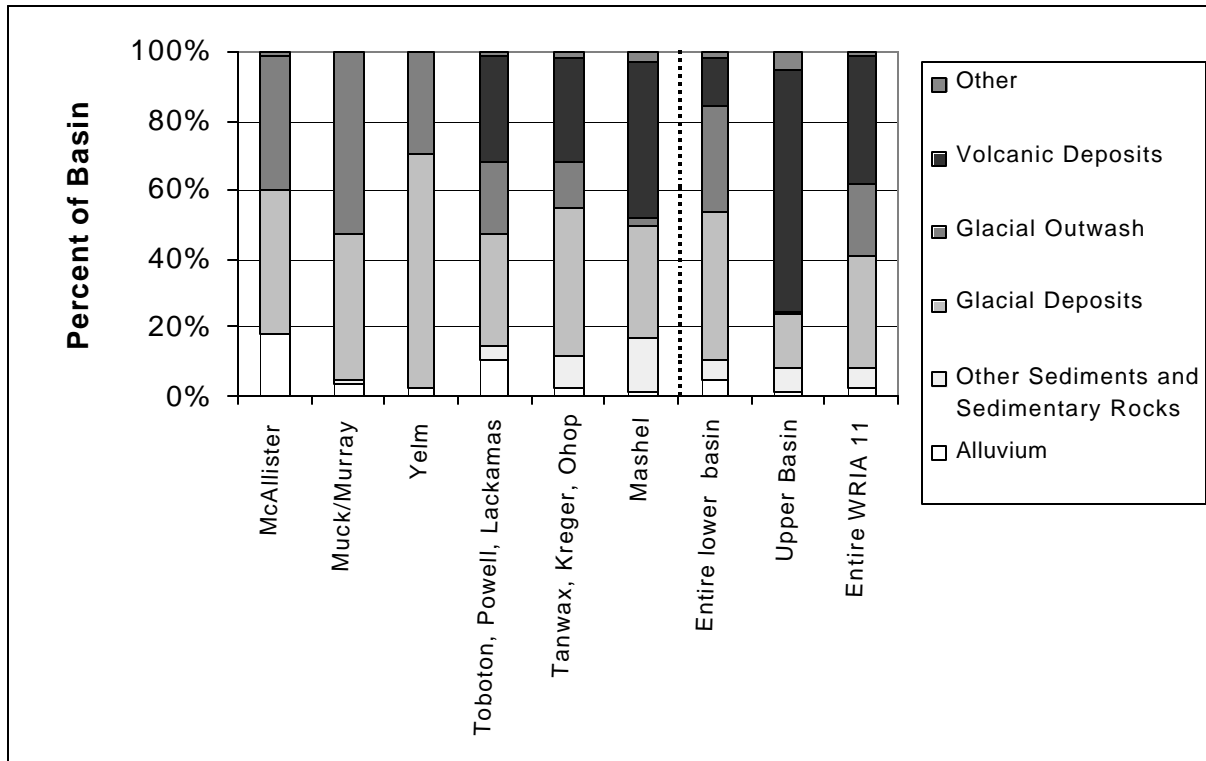


Figure 2-5. Percent of each subbasin and the study area as a whole in each of the major geologic groups.



Table 2-5. Percent of geologic types in each subbasin.

<b>Rock Type</b>	<b>Map Symbol</b>	<b>Description</b>	<b>McAllister</b>	<b>Muck/Murray</b>	<b>Yelm</b>	<b>Toboton, Powell, Lackamas</b>	<b>Tanwax, Kregger, Ohop</b>	<b>Mashel</b>	<b>Entire lower basin</b>	<b>Upper Basin</b>	<b>Entire WRIA 11</b>
Sediments and Sedimentary Rocks	Qa	Alluvium	18.00%	4.00%	3.00%	11.00%	3.00%	1.00%	5.00%	1.00%	3.00%
		Peat deposits									
	Qp		-	1.00%	-	-	2.00%	-	1.00%	-	0.00%
	Qls	Landslide debris	-	-	-	-	-	-	-	1.00%	0.00%
	Qc, #c, ec2	Continental sediments	-	0.00%	-	4.00%	8.00%	16.00%	5.00%	6.00%	5.00%
	@Em	Marine sedimentary rocks	-	-	-	-	-	0.00%	0.00%	-	0.00%
Glacial Deposits	Qgd, Qgp, Qad, Qap	Undifferentiated glacial drift	37.00%	3.00%	21.00%	17.00%	10.00%	33.00%	16.00%	15.00%	15.00%
	Qga, Qgo, Qgos, Qgog, Qao	Outwash deposits	39.00%	53.00%	29.00%	21.00%	14.00%	2.00%	31.00%	1.00%	20.00%
	Qgt	Till	5.00%	39.00%	46.00%	16.00%	35.00%	1.00%	28.00%	-	17.00%
Volcanic Deposits	Qva, #va, @va, Eva, @Eva	Andesite (lava) flows	-	-	0.00%	8.00%	14.00%	22.00%	7.00%	38.00%	19.00%
		Lahars									
	Ovl		-	-	-	-	1.00%	-	0.00%	2.00%	1.00%
	#vc, #@vc, @vc, @Evc, Evc	Volcaniclastic rocks	-	-	-	23.00%	11.00%	22.00%	6.00%	26.00%	14.00%
	#vt, #@vt, @Evt	Tuff	-	-	-	-	6.00%	3.00%	1.00%	2.00%	2.00%
Other	#ia, #ig, #igd, #iq, #ib, #@ida, #@ian, #@id	Intrusive rocks, granite, granodiorite, quartz diorite, diorite, dacite andesite	-	-	-	-	0.00%	3.00%	1.00%	1.00%	0.00%
	Glac	Present-day glaciers	-	-	-	-	-	-	-	2.00%	1.00%
	OW	Open Water	1.00%	0.00%	0.00%	1.00%	2.00%	0.00%	1.00%	2.00%	1.00%

## **PRECIPITATION**

Precipitation is the primary determinant of runoff in a watershed. The purpose of this section of the assessment is to characterize the spatial and temporal variation in precipitation in the lower Nisqually Basin.

Forty-three National Climatic Data Center (NCDC) cooperative weather stations having precipitation data are located within or near the lower Nisqually Basin (Figure 2-6, Table 2-6). The stations in Table 2-6 represent all stations between Latitude N 46° 30" to N 47° 15", and Longitude W121° 30" to W 123°. Not all climate stations are currently active, and several may contain longer records than those listed in Table 2-6.

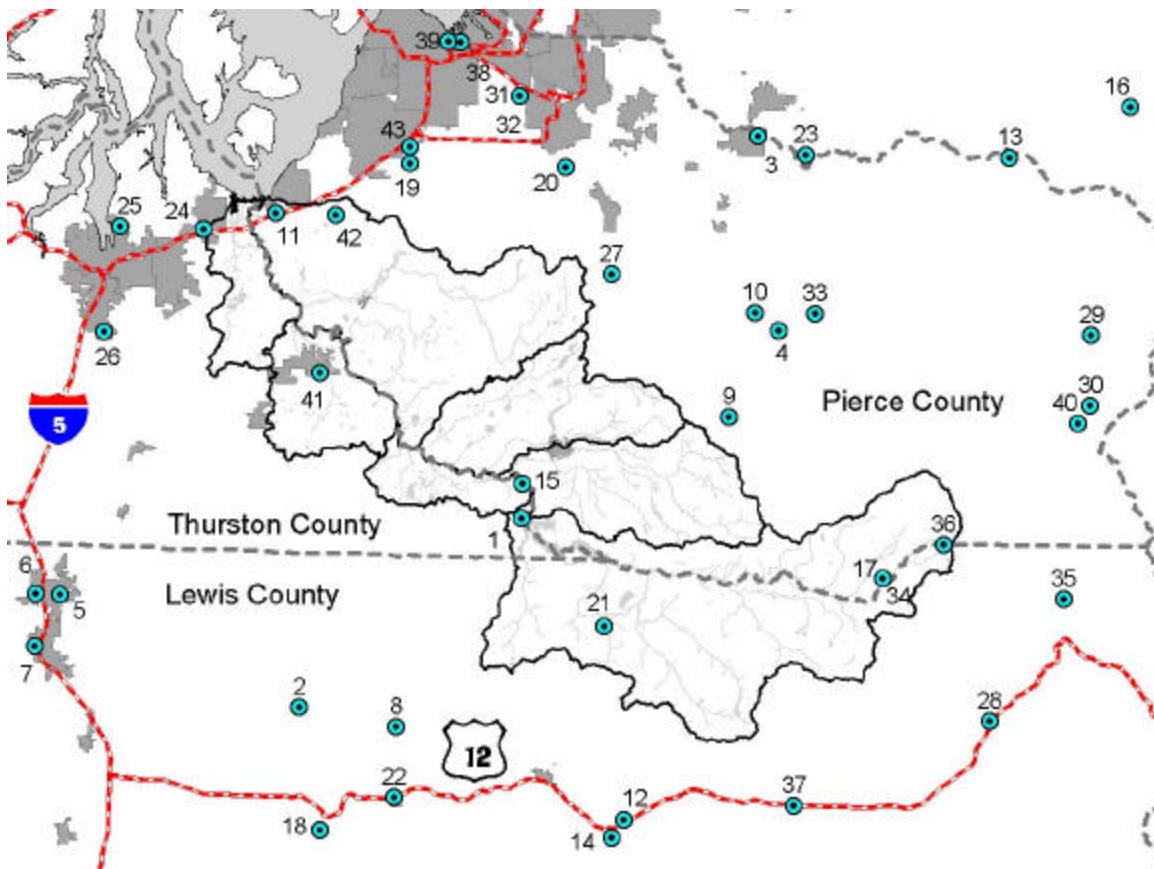


Figure 2-6. National Climatic Data Center (NCDC) climate stations located in the vicinity of WRIA 11. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage), fish-bearing streams and water bodies (shown in gray), and WRIA boundaries; WDOT (2001) - city boundaries (shown in dark gray) and principal highways; NCDC (2001) - climate station locations.

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Level 1 Assessment*

Table 2-6. National Climatic Data Center (NCDC) Cooperative stations located between Latitude N 46° 30" and N 47° 15", and Longitude W121° 30" to W 123° having precipitation records. Refer to Figure 2-6 for station locations.

Map #	Coop#	Station Name	Elevation (feet)	Precipitation data availability:					
				Hourly		Daily		Monthly	
				From	To	From	To	From	To
1	450094	Alder Dam Camp	1,303			6/48	2/54	1919	1954
2	450142	Alpha	722	7/53	11/62			1927	1936
3	450945	Buckley 1 NE	685			1/31	10/00	1919	2000
4	451113	Carbonado 8 SSE	1,641	12/57	6/62	12/57	3/62	1957	1962
5	451276	Centralia	185			1/31	11/00	1919	2000
6	451277	Centralia 1 W	185	9/67	10/00				
7	451330	Chehalis	180	7/48	4/68	4/50	9/51	1949	1951
8	451457	Cinebar 2 E	1,040	7/48	10/00	4/50	9/51	1949	1951
9	452493	Electron Headworks	1,732	7/48	7/80	6/48	5/80	1943	1980
10	452722	Fairfax	1,421	7/48	4/50	10/48	4/50	1919	1950
11	452952	Fort Lewis Golf Course	299			2/00	6/00	2000	2000
12	453177	Glenoma 1 W	840			3/66	11/00	1966	2000
13	453357	Greenwater	1,730	7/48	12/98	1/39	5/81	1939	1981
14	454286	Glenoma 1 W	781			10/32	11/65	1919	1965
15	454360	La Grande	961			2/54	4/83	1954	1983
16	454634	Lester	1,631	7/60	11/74				
17	454764	Longmire Rainier NPS	2,762	10/78	10/00	12/78	12/00	1978	2000
18	455110	Mayfield Power Plant	280			3/80	10/00	1980	2000
19	455149	Mc Chord AFB	289	7/48	12/78	4/50	9/51	1949	1951
20	455224	McMillin Reservoir	579	7/48	10/00	3/41	11/00	1941	2000
21	455425	Mineral	1,470			6/48	12/79	1930	1979
22	455655	Mossyrock	679			6/48	6/49	1948	1949
23	455704	Mud Mountain Dam	1,308	7/48	10/00	1/39	11/00	1939	2000
24	456104	Olympia Forest HQ	200			6/48	9/52	1919	1952
25	456109	Olympia Priest Pt Pa	30			6/48	12/55	1931	1955
26	456114	Olympia AP	195	7/48	10/00	1/48	12/00	1941	2000
27	456201	Orting 4 S	351			10/48	3/50	1949	1950
28	456262	Packwood	1,060			6/48	9/00	1931	2000
29	456381	Parkway	2,641					1931	1944
30	456385	White River RS	3,553	7/48	9/66	11/48	7/66	1930	1966
31	456803	Puyallup 2 W Exp Stn.	50			1/31	7/95	1919	1995
32	456808	Puyallup 3 W	30			12/48	4/49	1949	1949
33	456892	Rainier Carbon River	1,735	7/48	10/00	6/48	3/74	1926	1973
34	456894	Longmire Rainier NPS	2,763			1/31	11/78	1919	1978
35	456896	Rainier Ohanapecosh	1,950	8/48	10/00	7/48	12/00	1927	2000
36	456898	Rainier Paradise Rng	5,427			6/48	12/00	1919	2000
37	456909	Randle 1 E	900	8/54	10/00	6/48	11/00	1926	2000
38	458278	Tacoma 1	25			3/82	12/00	1982	2000
39	458286	Tacoma City Hall	269	8/48	3/53	6/48	12/81	1919	1981
40	459171	White River RS	3,504	9/66	3/81	12/66	12/75	1966	1975
41	459485	Yelm	351	7/48	12/78	11/49	9/51	1949	1951
42	999999	Gray AAF	295			6/60	12/70		
43	999999	Tacoma McChord AFB	289			12/46	12/70		

## **AVERAGE PRECIPITATION**

The Oregon Climate Service (1998) has published digital maps of mean annual and monthly precipitation for the State of Washington, based on available precipitation records for the period 1961-1990. The Oregon Climate Service maps were produced using techniques developed by Daly et al (1994), which use an analytical model that combines point precipitation data and digital elevation model (DEM) data to generate spatial estimates of annual and monthly precipitation. As such, the precipitation maps available from the Oregon Climate Service incorporate precipitation data from the local stations shown in Figure 2-6. For further information on how these maps are produced the reader is referred to Daly and others (1994), or the on-line overview available at <http://www.ocs.orst.edu/prism/overview.html>.

Mean annual precipitation within the lower Nisqually Basin generally increases as elevation increases (Figure 2-7). The average annual precipitation in the lower portions of the watershed ranges from 33 to 50 inches. On average, the upper basin and the upper portions of the Tanwax/Kreger/Ohop and Mashel subbasins receive greater than 70 inches of precipitation annually.

Mean monthly precipitation for each subbasin was also estimated using data available from the Oregon Climate Service (1998). Mean monthly precipitation varies little among the subbasins, with the exception of the Mashel subbasin and the upper basin, which tend to be significantly wetter, reflecting the higher elevations found in those subbasins (Figures 2-8, 2-9, and 2-10). Mean monthly precipitation values are highest in all subbasins in December, and lowest in July.

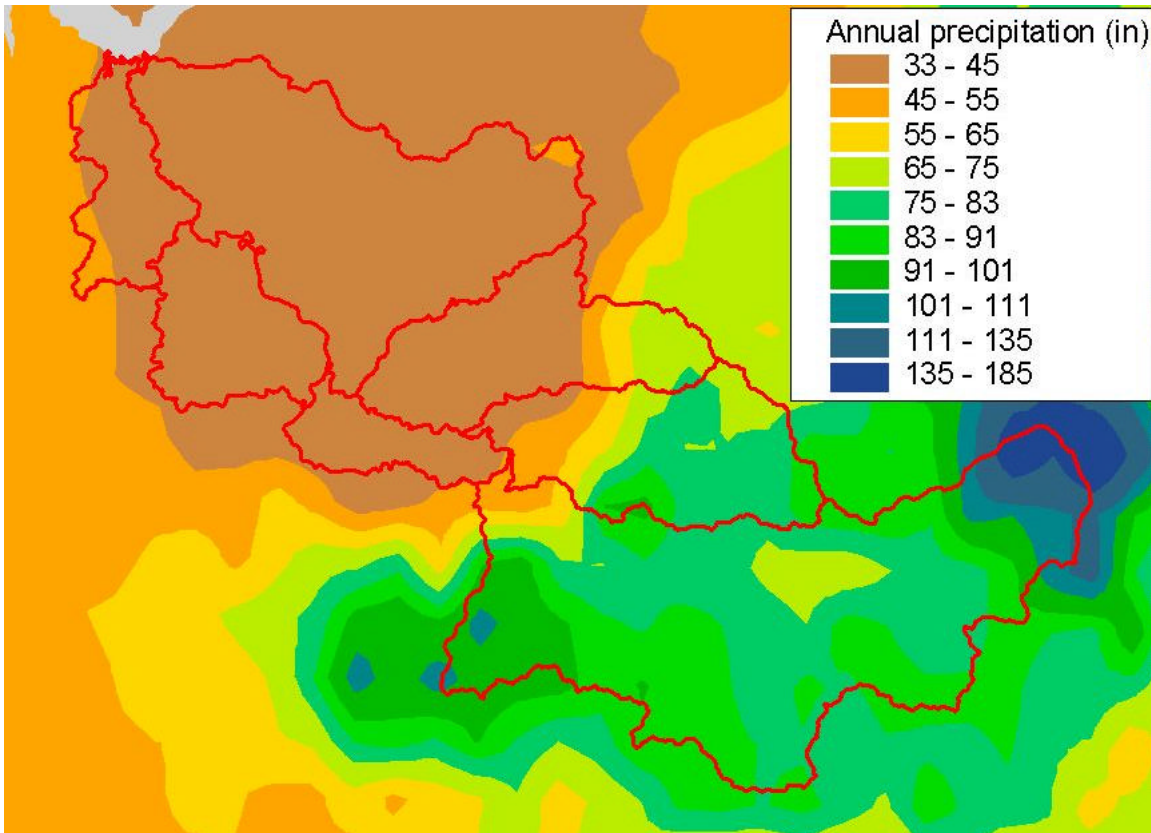


Figure 2-7. Mean annual precipitation (inches) for the period 1961-1990. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage); Oregon Climate Service (1998) - mean annual precipitation.

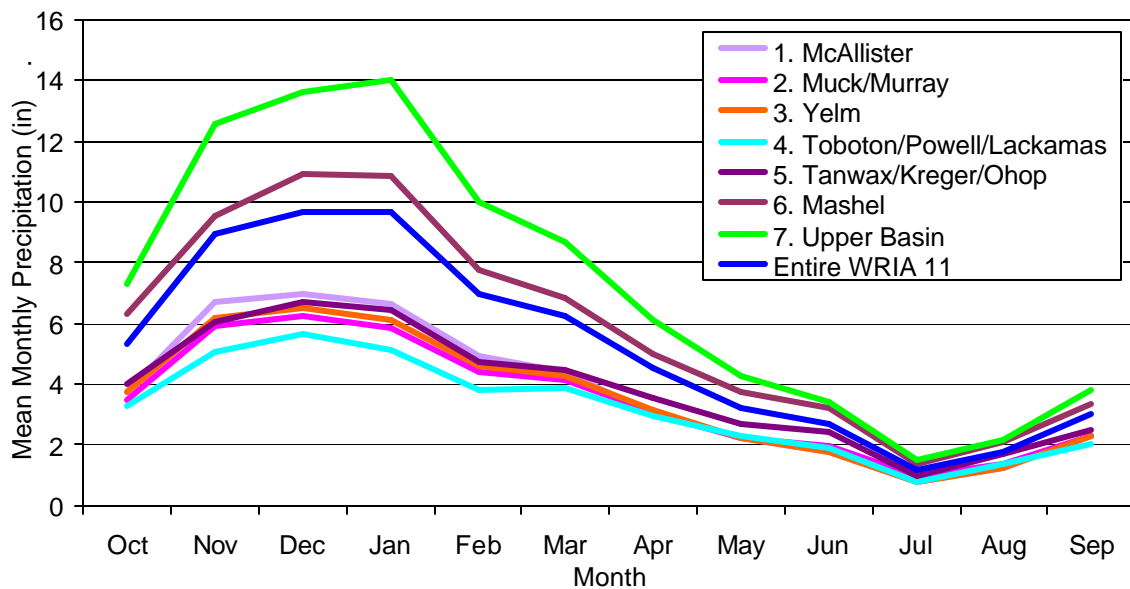


Figure 2-8. Mean monthly precipitation distribution. Data Source: Oregon Climate Service (1998) - mean monthly precipitation.

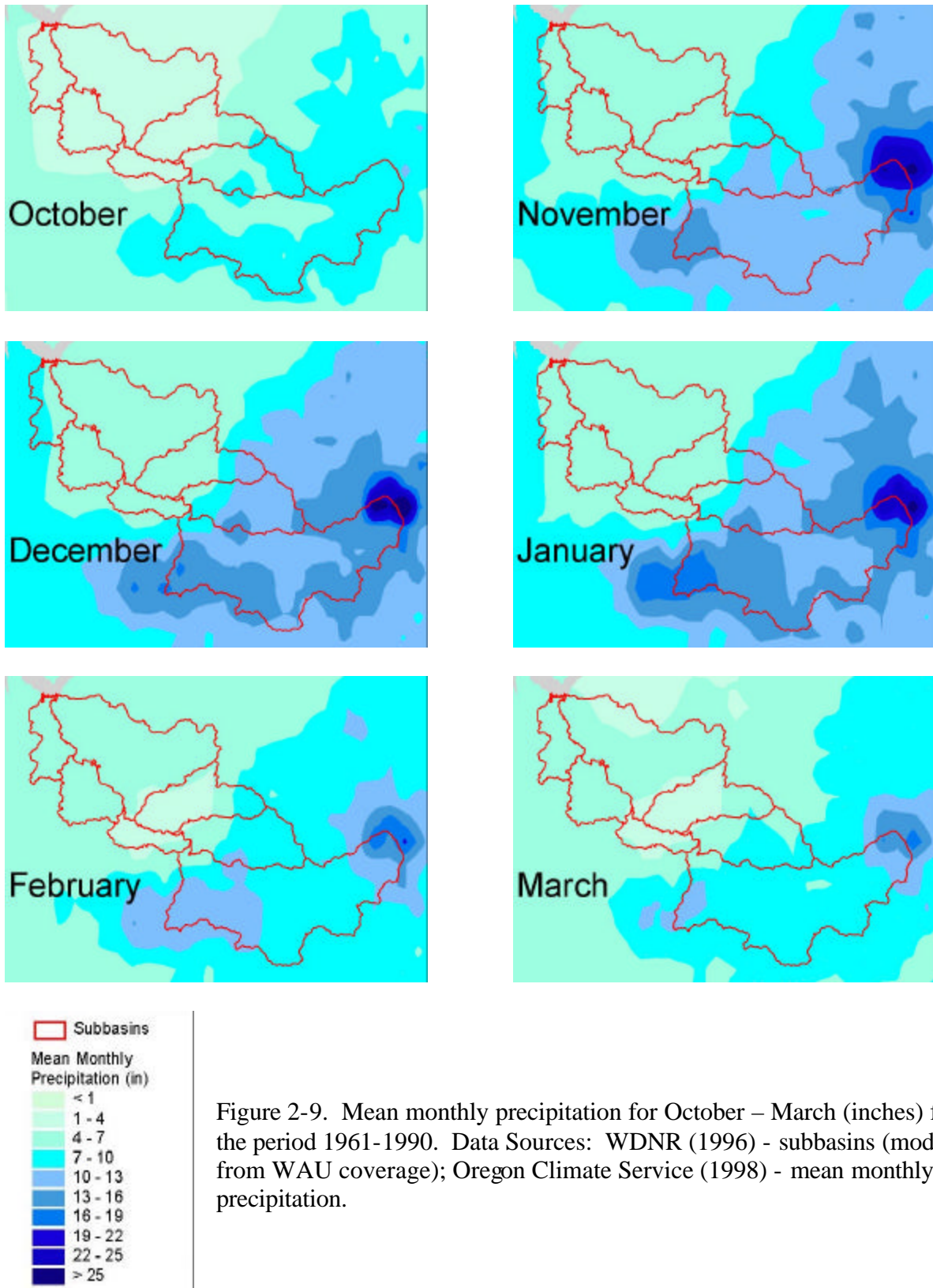


Figure 2-9. Mean monthly precipitation for October – March (inches) for the period 1961-1990. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage); Oregon Climate Service (1998) - mean monthly precipitation.



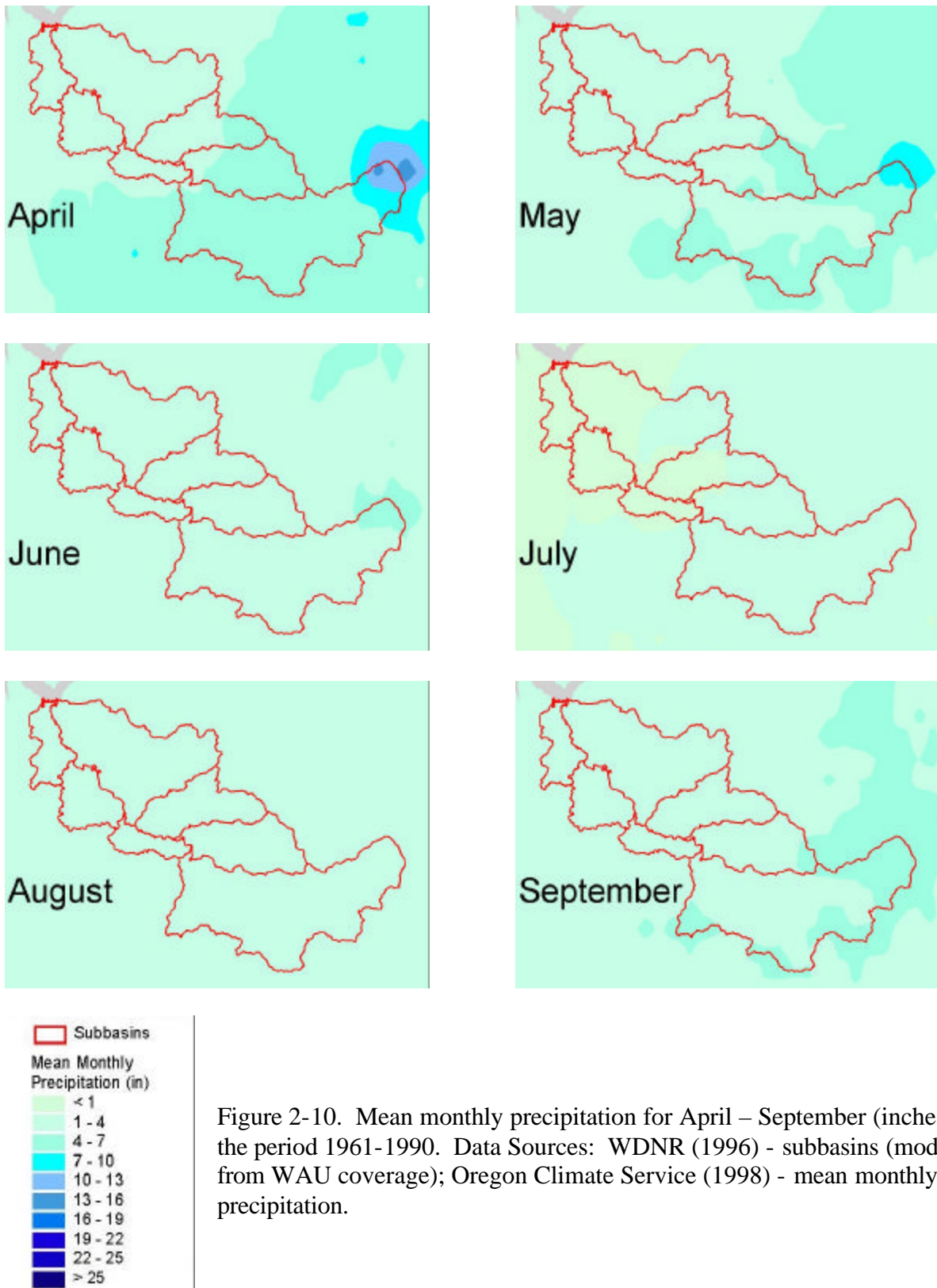


Figure 2-10. Mean monthly precipitation for April – September (inches) for the period 1961-1990. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage); Oregon Climate Service (1998) - mean monthly precipitation.

## **YEAR-TO-YEAR VARIABILITY**

Year-to-year variability in precipitation was assessed using long-term precipitation records from climate stations within or adjacent to the lower Nisqually Basin. Very few precipitation stations are located in the lower Nisqually Basin (Figure 2-6), and those that are have short and irregular data records (Table 2-6). For the purposes of this portion of the assessment five stations were selected for analysis; two located within the lower Nisqually Basin (Alder Dam Camp and Yelm), one that is located immediately outside the assessment area to the northwest (Olympia Forest HQ), one located outside the basin to the southwest (Centralia), and one located outside the basin to the northeast (Puyallup 2W Exp. Stn.). All five stations originally appeared to have sufficiently long records to be considered for this assessment. However, upon closer inspection of the record timelines for these five stations (Figure 2-11), it was decided to drop the Yelm station because of its fragmented record. Other stations (e.g., McMillin Reservoir), although located relatively close to the boundary of the lower Nisqually Basin do not have as long of a data record as the stations that were selected (e.g., McMillin Reservoir has data available only from 1941-2000; twenty years shorter than the records from the Centralia and Puyallup 2W Exp. stations).

The two primary patterns of climatic variability that occur in the Pacific Northwest are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The two climate oscillations have similar spatial climate fingerprints, but very different temporal behavior (Mantua, 2001). One of the primary characteristics distinguishing these trends are that PDO events persist for 20-to-30 year periods, while ENSO events typically persist for 6 to 18 months (Mantua, 2001). Several studies (Mantua et al. 1997, Minobe 1997, Mote et al, 1999) suggest that five distinct PDO cycles have occurred since the late 1800's (Table 2-7).

Changes in Pacific Northeast marine ecosystems have been correlated with PDO phase changes. Warm/dry phases have been correlated with enhanced coastal ocean productivity in Alaska and decreased productivity off the west coast of the lower 48 states, while cold/wet phases have resulted in opposite patterns of ocean productivity (Mantua, 2001).



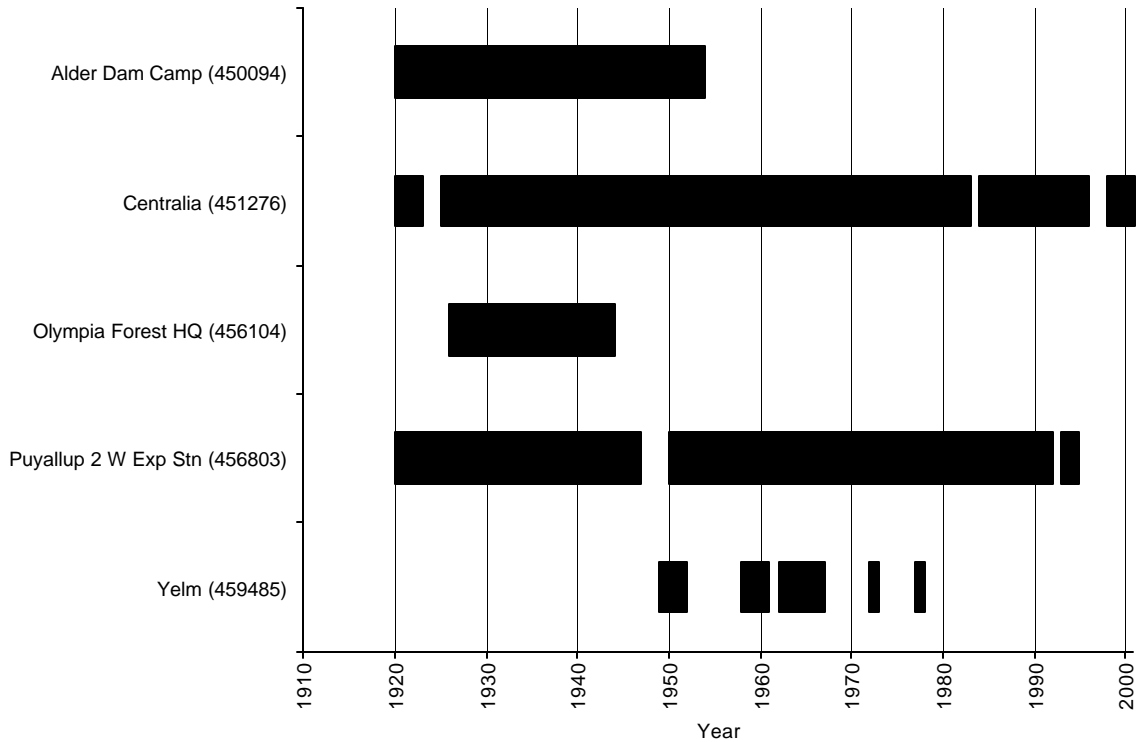


Figure 2-11. Timelines of five National Climatic Data Center (NCDC) Cooperative stations having long-term precipitation records that were considered for analysis. Refer to Figure 2-6 for station locations.

Table 2-7. Recent Pacific Decadal Oscillation (PDO) cycles in the Pacific Northwest (source: Mantua et al. 1997; Minobe 1997; Mote et al. 1999).

PDO cycle	Time period
Cool/wet	1890-1924
Warm/dry	1925-1946
Cool/wet	1947-1976
Warm/dry	1977 –1995
Cool/wet	1995 – present (estimated)

Statistical techniques used by Envirovision Corporation (2000) in the Chehalis River basin were applied to annual precipitation records available from the Alder Dam Camp, Centralia, Olympia Forest HQ, and Puyallup 2 W Exp climate stations to understand whether local trends follow the documented PDO cycles. Data from these stations was processed in the following manner:

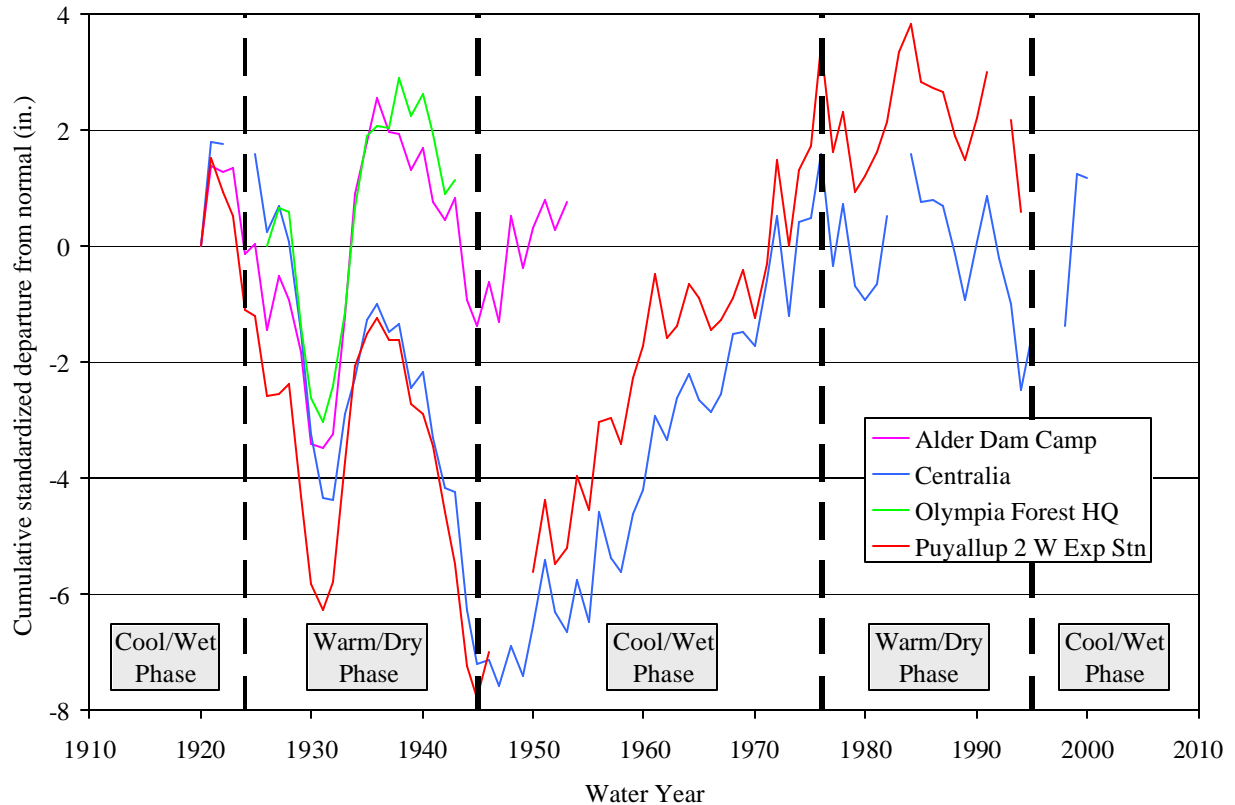
1. The mean and standard deviation was calculated for the annual precipitation at each station over the period of record
2. A standardized departure from normal was calculated for each year by subtracting the mean annual precipitation from the annual precipitation for a given year, and dividing by the standard deviation
3. A cumulative standardized departure from normal was then calculated by adding the standardized departure from normal for a given year to the cumulative standardized departure from the previous year (the cumulative standardized departure from normal for the first year in a station record was set to zero).

This approach of using the cumulative standardized departure from normal provides a way to better-illustrate patterns of increasing or decreasing precipitation over time by reducing year-to-year variations in precipitation, thus compensating for the irregular nature of the data set. Values for the cumulative standardized departure from normal increase during wet periods and decrease during dry periods. Results for the four stations are given in Figure 2-12.

Precipitation patterns from the four local stations shown in Figure 2-12 follow the documented regional trends (Table 2-7) reasonably well for the cool/wet phase of that began in 1947, and for the warm/dry phase that ended in 1995, although the shift between these two phases appears to have occurred somewhere around 1984. The data shown in Figure 2-12 for the period 1925-46 suggests that there may have been an additional cool/wet phase within this regionally documented warm/dry phase. Current conditions appear to be trending towards a cooler wetter phase than has been observed since the late 1970s. Data, however, are not conclusive.

The information on precipitation presented in this section was used in the streamflow assessment (Chapter 5.1) and the groundwater assessment (Chapter 5.2). In addition, this information would be necessary if any level II modeling of basin hydrology is required. It should be kept in mind that the results presented in this section represent average conditions for annual (Figure 2-7) and monthly (Figures 2-8, 2-9, and 2-10) conditions within the subbasins of the lower Nisqually Basin. Additional analysis, beyond the scope of this level I assessment, would be required to address the variability in these annual and/or monthly estimates. Although the number of climate stations within the lower Nisqually Basin are few, and the station data records are in many cases of short duration

and/or discontinuous, the available data was sufficient for completing the level I assessment.



**Figure 2-12. Cumulative standardized departure from normal of annual precipitation for four National Climatic Data Center (NCDC) Cooperative stations having long-term precipitation records in the vicinity of the Lower Nisqually Basin. Regional PDO cycles (Table 2-7) are shown as vertical dashed lines.**

## **LAND USE**

Land use within a watershed may directly affect water availability through changes in watershed parameters affecting runoff (e.g., impermeable area associated with certain land uses, changes in vegetation patterns), as well as indirectly through the variable water demand associated with different water uses. The purpose of this section of the assessment is to characterize current land use within the subbasins found in the lower Nisqually Basin.

Current land use in the lower Nisqually Basin was estimated using existing GIS coverages available from Thurston and Pierce counties. For Pierce County the current land use was estimated using the Existing Land Use coverage (COND\_CD) supplemented by the Current Zoning (ZONING) coverage. For Thurston County the current land use was estimated using the Zoning coverage (COZONE). No coverages were available for Thurston County on actual existing land use. The GIS coverages supplied by the counties contained many more categories than was considered practical for summarizing land use conditions that effect stream flow. In addition, we felt it necessary to combine the information from both counties into a single, consistent, format. Consequently, the categories supplied in the GIS coverages were combined into eight categories for the purposes of this assessment (Figure 2-13; Table 2-8). Appendix 2-1 contains further details on assignment of current land use categories.

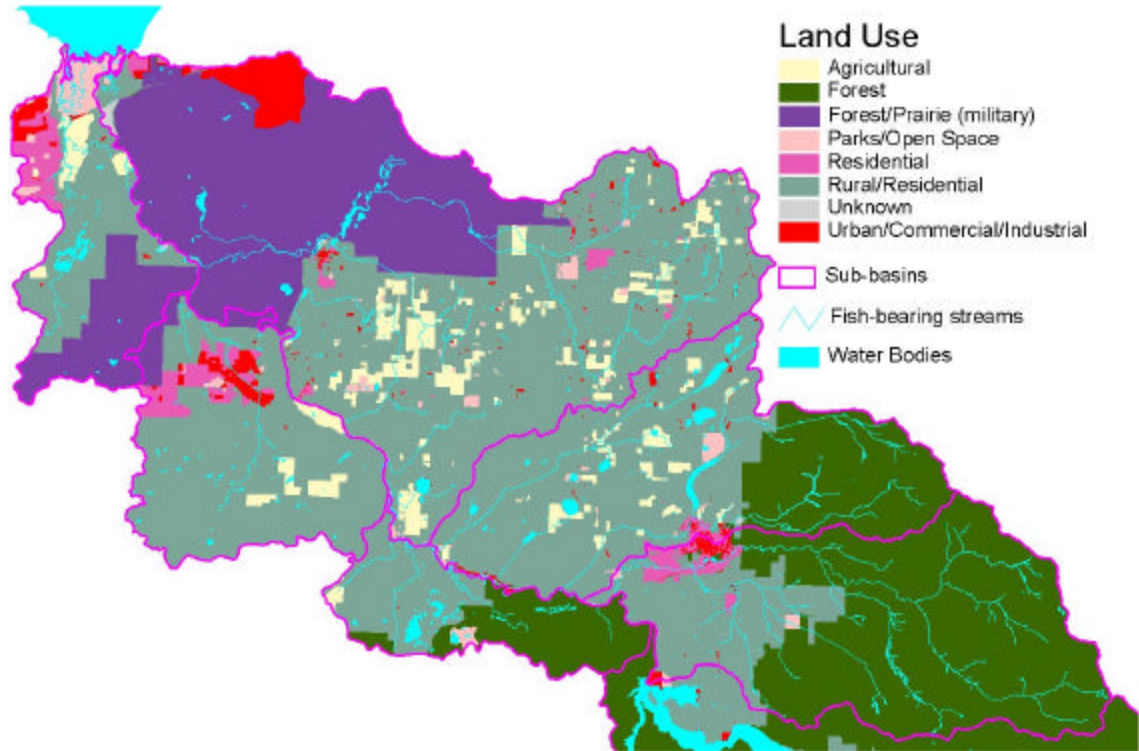


Figure 2-13. Current land use in the Lower Nisqually Basin. Descriptions of land use categories are given in Table 2-8. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage), fish-bearing streams, and water bodies; Thurston County GeoData Center (2001), Pierce County GIS Department (2001) - existing land use and zoning coverages.

Table 2-8. Descriptions of current land use types found in the lower Nisqually Basin.

Land use Category	Description
Agricultural	Current land use is primarily agricultural (e.g., row crops, pasture, etc).
Forest	Current land use is primarily forest management
Forest/Prairie (military)	Areas on the Fort Lewis military reservation that are primarily in an undeveloped state. This area is primarily forested, however, included within this category are large tracts of non-forested prairie. Much of this area is used for military training exercises.
Parks/Open Space	Areas currently in some type of park/open space land use. May or may not be forested. Includes undeveloped and developed areas (e.g., playfields, city parks, etc).
Residential	Current land use is primarily single or multi-unit residential. Parcels are predominately in a developed state.
Rural/Residential	Low-density residential parcels. Significant portions of these parcels may be in an undeveloped state (e.g., forested) or may include agricultural land.
Urban/Commercial/Industrial	Areas that are predominately developed for urban, commercial, or industrial uses.
Unknown	Current land use is unknown

The majority of the WRIA lies in areas designated as rural residential. Rural/Residential land use ranges from 22% (in the Mashel subbasin) to 80% (in the Yelm subbasin), and makes up 49% of the lower Nisqually Basin overall (Figures 2-13 and 2-14).

Lands designated as forest or forestry products production also make up a large portion of the WRIA. Much of the forested area in the lower basin lies in the Mashel subbasin and on the Fort Lewis Military Reservation. The category “Forest/Prairie (military)” was defined to represent the undeveloped portions of the Fort Lewis military reservation, which includes a mix of forest and open prairie areas. Forest/Prairie areas make up a significant portion of the McAllister and Muck/Murray subbasins (34% and 38% of subbasin area respectively) (Figure 2-14). The true area in forest production is also probably under-represented, as some forested areas are probably included in the “Rural/Residential” category (i.e., many of the rural residential properties contain significant area of forest land).

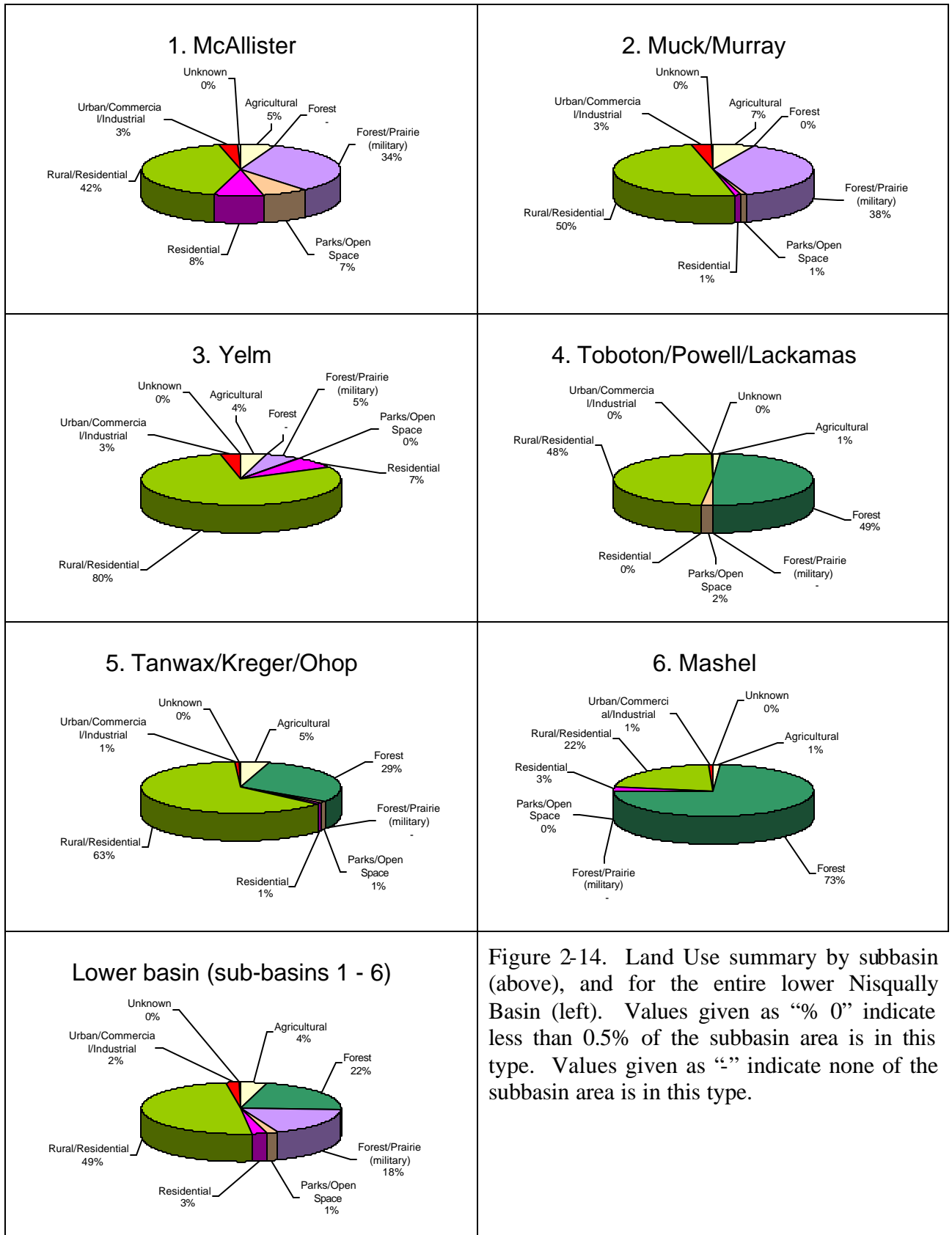


Figure 2-14. Land Use summary by subbasin (above), and for the entire lower Nisqually Basin (left). Values given as “% 0” indicate less than 0.5% of the subbasin area is in this type. Values given as “-” indicate none of the subbasin area is in this type.

Agricultural land use ranges from 1% of subbasin area (for the Mashel and Toboton/Powell/Lackamas subbasins) to 7% (for the Muck/Murray subbasin), and comprises 4% of the lower Nisqually Basin overall (Figures 2-13 and 2-14). The true area in agricultural production is probably under-represented, as some agricultural areas are probably included in the “Rural/Residential” category (i.e., many of the rural residential properties contain significant area of agricultural or “hobby” farm land).

Subbasin area in Parks/Open Space makes up 1% of the lower Nisqually Basin overall (Figure 2-14). Residential land use ranges from almost 0% (in the Toboton/Powell/Lackamas subbasin) to 8% (in the McAllister subbasin), and covers 3% of the lower Nisqually Basin overall. Urban/Commercial/Industrial land use is concentrated in limited areas and covers 2% of the lower Nisqually Basin. Areas in unknown land use make up a very small percentage of the subbasins (less than 0.5%).

Information on land use is provided in this level I assessment solely for the purposes of characterizing the subbasins, and to assess the utility of existing information should any level II modeling of basin hydrology be recommended. The data gaps in the current land use information are 1) a lack of an adequate existing land use GIS coverage for Thurston County, and 2) a lack of distinction within lands classified as rural/residential as to what proportion of these areas are in a forest or agricultural use.

## **DAMS**

Dams directly affect water availability through regulation of stream flow. The purpose of this section of the assessment is to characterize dams that are present in the lower Nisqually Basin.

Information on locations of dams in the Nisqually Basin is available in digital format from the WDOE. There are 18 documented dams in the WRIA, including the Centralia power canal, which diverts water from the mainstem Nisqually River at River Mile 26.2, and returns flow at River Mile 12.6 (Figure 2-15). Some of these facilities are small ponds (Table 2-9). The largest facilities include Alder dam, La Grande dam, Central Diversion Dam, McAllister Springs, and several dams forming large lakes. The information on dam locations presented here was adequate for the purposes of this assessment.

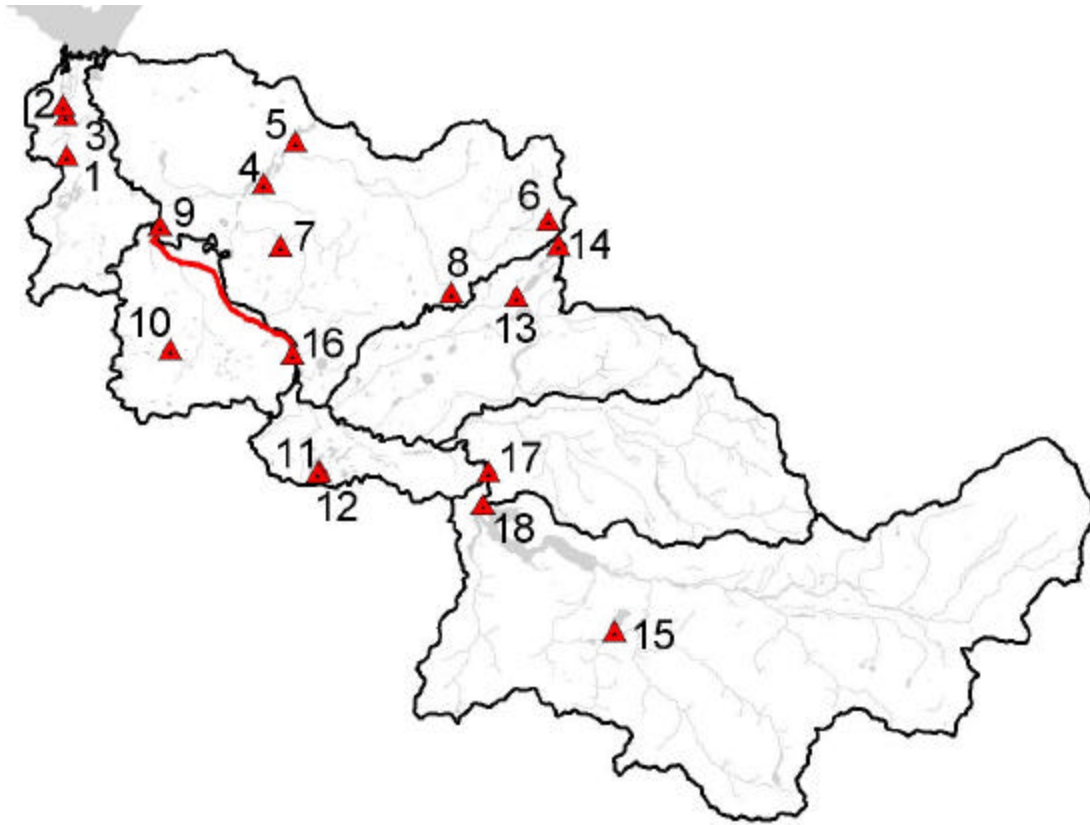


Figure 2-15. Dams in the Nisqually River Basin. The Centralia power canal is shown in red. Fish-bearing streams and water bodies are shown in gray. Data Sources: WDNR (1996) - subbasins (modified from WAU coverage), Centralia power canal, fish-bearing streams, water bodies, and WRIA boundaries; WDOE (2001) - dam locations.



Table 2-9. Dams in the Nisqually River Basin. Refer to Figure 2-15 for locations.

Map #	Stream	Dam Name	Dam owner	Year constructed
<b>1. McAllister Subbasin</b>				
1	McAllister Creek	McAllister Spring Lake Dam	City of Olympia	1944
2	McAllister Creek trib.	Nisqually Trout Farm Dam	Nisqually Trout Farm	1937
3	Medicine Creek	Medicine Creek Reservoir Dam		1947
<b>2. Muck/Murray Subbasin</b>				
4	Muck Creek	Chambers Lake Dam	Dept. of Defense, U.S. Army	1967
5	Muck Creek	Johnson Marsh Dam	Dept. of Defense, U.S. Army	1976
6	South Creek trib.	Holder Water Ski Pond		1986
7	Murray Creek trib.	Serene Lake		1971
8	Nisqually River trib.	Thompson Dam		1969
9	Nisqually River trib.	Oxbow Lake	Dept. of Defense, U.S. Army	1979
<b>3. Yelm Subbasin</b>				
10	Nisqually River trib.	Winsor Water-ski Pond		1991
<b>4. Toboton/Powell/Lackamas Subbasin</b>				
11	Nisqually River trib.	Beaver Dam (Clearwood Dam No. 1)	Weyerhaeuser Properties	1972
12	Nisqually River trib.	Muskrat Dam (Clearwood Dam No. 2)	Weyerhaeuser Properties	1972
<b>5. Tanwax/Kreger/Ohop Subbasin</b>				
13	Tanwax Creek	Tanwax Lake Dam	Tanwax Inc.	1920
14	Lake Kapowsin trib.	Lindstrom Dam No. 1		1965
<b>7. Upper Basin Subbasin</b>				
15	Mineral Creek trib.	Mineral Lake Dam	Washington Dept. of Wildlife	1960
<b>8. Mainstem Nisqually River Subbasin</b>				
16	Nisqually River	Centralia Diversion Dam	City of Centralia	
17	Nisqually River	La Grande Dam	Tacoma Public Utilities	1945
18	Nisqually River	Alder Dam	Tacoma Public Utilities	1945

## APPENDIX 2-1. ASSIGNMENT OF CURRENT LAND USE

The following describes how current land uses were assigned for areas in the Lower Nisqually Basin using attributes from GIS coverages supplied by Thurston and Pierce Counties. For Thurston County the current land use was assigned using the Zoning coverage (COZONE), no coverages being available on actual existing land use. For Pierce County the current land use was assigned using the Existing Land Use coverage (COND\_CD) supplemented by the Current Zoning (ZONING) coverage.

### Areas within Thurston County:

Land use Assigned	Includes areas where:
<b>Agricultural</b>	Zoning code = AG (Agricultural District). Zoning code = LTA (Long-Term Agriculture District). Zoning code = NA (Nisqually Agricultural District).
<b>Forest</b>	Zoning code = LTF (Long-Term Forestry District).
<b>Forest/ Prairie (military)</b>	Zoning code = MR (Military Reservation District).
<b>Parks/Open Space</b>	Zoning code = OS-I (Open Space Institutional). Zoning code = P/OS (Parks/Open Space). Zoning code = PP (Public Preserves District).
<b>Residential</b>	Zoning code = LD (Low Density Resident). Zoning code = LD 3-6 (Low Density 3-6). Zoning code = MD (Moderate Density Residential). Zoning code = MPC (Master Planned Community). Zoning code = R-14 (High Density Residential). Zoning code = R-4 (Low Density Residential). Zoning code = R-6 (Moderate Density Residential). Zoning code = VC (Village Center).
<b>Rural/ Residential</b>	Zoning code = MGSA (McAllister Geologically Sensitive Area District). Zoning code = RR1/1 (Rural Residential--One Dwelling Unit Per Acre). Zoning code = RR1/2 (Rural Residential--One Dwelling Unit Per Two Acres). Zoning code = RR1/5 (Rural Residential--One Dwelling Unit Per Five Acres). Zoning code = RR1/5 (Rural Residential--One Dwelling Unit Per Five Acres). Zoning code = RR2/1 (Rural Residential--Two Dwelling Units Per Acre). Zoning code = RRR1/5 (Rural Residential/Resource--One Dwelling Unit Per Five Acres).
<b>Urban/ Commercial/ Industrial</b>	Zoning code = AC (Arterial Commercial District). Zoning code = BP (Business Park). Zoning code = C-1 (Commercial Zone). Zoning code = C-2 (Heavy Commercial Zone). Zoning code = C-3 (Large Lot Commercial). Zoning code = CBD (Central Business District). Zoning code = GC (General Commercial). Zoning code = HC (Highway Commercial District). Zoning code = HD (High Density Residential). Zoning code = HPBD-C (Hawks Prairie Business District). Zoning code = I (Industrial District). Zoning code = ID (Institutional District). Zoning code = LI (Light Industrial).

Land use Assigned	Includes areas where:
	Zoning code = ME (Mineral Extraction). Zoning code = MHDC (Mixed Use High Density). Zoning code = NC (Neighborhood Convenience District).
<b>Unknown</b>	All remaining areas

**Areas within Pierce County:**

Land use assigned	Includes areas where:
<b>Agricultural</b>	Existing use = "(blank)" and Zoning = "Agricultural". Existing use = "Other" and Zoning = "Agricultural". Existing use = "Resource Land" and Zoning = "Agricultural". Existing use = "Vacant" and Zoning = "Agricultural".
<b>Forest</b>	Existing use = "(blank)" and Zoning = "Designated Forest Land". Existing use = "Other" and Zoning = "Designated Forest Land". Existing use = "Resource Land" and Zoning = "(blank)". Existing use = "Resource Land" and Zoning = "DuPont". Existing use = "Resource Land" and Zoning = "Eatonville". Existing use = "Resource Land" and Zoning = "Designated Forest Land". Existing use = "Vacant" and Zoning = "Designated Forest Land". Existing use = "Vacant" and Zoning = "Fort Lewis".
<b>Forest/ Prairie (military)</b>	Existing use = "(blank)" and Zoning = "Fort Lewis".
<b>Parks/Open Space</b>	Existing use = "Open Space/Recreation" and Zoning = "(all)".
<b>Residential</b>	Existing use = "Education" and Zoning = "(all)". Existing use = "Group Home/Other" and Zoning = "(all)". Existing use = "Multi-Family Residential" and Zoning = "(all)". Existing use = "(blank)" and Zoning = "Moderate Density Single Family". Existing use = "(blank)" and Zoning = "Rural Activity Center". Existing use = "(blank)" and Zoning = "Rural Neighborhood Center". Existing use = "Mobile Home" and Zoning = "DuPont". Existing use = "Mobile Home" and Zoning = "Eatonville". Existing use = "Mobile Home" and Zoning = "Moderate Density Single Family". Existing use = "Mobile Home" and Zoning = "Rural Activity Center". Existing use = "Mobile Home" and Zoning = "Rural Neighborhood Center". Existing use = "Mobile Home" and Zoning = "Roy". Existing use = "Other" and Zoning = "Moderate Density Single Family". Existing use = "Other" and Zoning = "Rural Activity Center". Existing use = "Other" and Zoning = "Roy". Existing use = "Public Facilities" and Zoning = "Rural Activity Center". Existing use = "Public Facilities" and Zoning = "Rural Neighborhood Center". Existing use = "Quasi-Public Facilities" and Zoning = "Rural Activity Center". Existing use = "Single-Family Residential" and Zoning = "(blank)". Existing use = "Single-Family Residential" and Zoning = "DuPont". Existing use = "Single-Family Residential" and Zoning = "Eatonville". Existing use = "Single-Family Residential" and Zoning = "Moderate Density Single Family". Existing use = "Single-Family Residential" and Zoning = "Rural Activity Center". Existing use = "Single-Family Residential" and Zoning = "Rural Neighborhood Center". Existing use = "Single-Family Residential" and Zoning = "Roy". Existing use = "Vacant" and Zoning = "DuPont". Existing use = "Vacant" and Zoning = "Eatonville".

Land use assigned	Includes areas where:
	Existing use = "Vacant" and Zoning = " Moderate Density Single Family". Existing use = "Vacant" and Zoning = " Rural Activity Center". Existing use = "Vacant" and Zoning = " Rural Neighborhood Center". Existing use = "Vacant" and Zoning = " Roy".
<b>Rural/Residential</b>	Existing use = "(blank)" and Zoning = " Rural Ten". Existing use = "(blank)" and Zoning = " Rural Twenty". Existing use = "(blank)" and Zoning = " Rural Five". Existing use = "(blank)" and Zoning = " Reserve Ten". Existing use = "(blank)" and Zoning = " Reserve Five". Existing use = "Mobile Home" and Zoning = " Agricultural". Existing use = "Mobile Home" and Zoning = " Designated Forest Land". Existing use = "Mobile Home" and Zoning = " Rural Ten". Existing use = "Mobile Home" and Zoning = " Rural Twenty". Existing use = "Mobile Home" and Zoning = " Rural Five". Existing use = "Mobile Home" and Zoning = " Reserve Five". Existing use = "Other" and Zoning = " Rural Ten". Existing use = "Other" and Zoning = " Rural Twenty". Existing use = "Other" and Zoning = " Rural Five". Existing use = "Other" and Zoning = " Reserve Five". Existing use = "Public Facilities" and Zoning = " Rural Ten". Existing use = "Public Facilities" and Zoning = " Rural Twenty". Existing use = "Public Facilities" and Zoning = " Rural Five". Existing use = "Quasi-Public Facilities" and Zoning = " Rural Ten". Existing use = "Quasi-Public Facilities" and Zoning = " Rural Five". Existing use = "Resource Land" and Zoning = " Moderate Density Single Family". Existing use = "Resource Land" and Zoning = " Rural Ten". Existing use = "Resource Land" and Zoning = " Rural Twenty". Existing use = "Resource Land" and Zoning = " Rural Five". Existing use = "Resource Land" and Zoning = " Roy". Existing use = "Resource Land" and Zoning = " Reserve Five". Existing use = "Single-Family Residential" and Zoning = " Agricultural". Existing use = "Single-Family Residential" and Zoning = " Rural Ten". Existing use = "Single-Family Residential" and Zoning = " Rural Twenty". Existing use = "Single-Family Residential" and Zoning = " Rural Five". Existing use = "Single-Family Residential" and Zoning = " Reserve Ten". Existing use = "Single-Family Residential" and Zoning = " Reserve Five". Existing use = "Vacant" and Zoning = " Rural Ten". Existing use = "Vacant" and Zoning = " Rural Twenty". Existing use = "Vacant" and Zoning = " Rural Five". Existing use = "Vacant" and Zoning = " Reserve Ten". Existing use = "Vacant" and Zoning = " Reserve Five".
<b>Urban/Commercial/ Industrial</b>	Existing use = "Commercial/Service" and Zoning = "(all)". Existing use = "Industrial" and Zoning = "(all)". Existing use = "(blank)" and Zoning = " DuPont". Existing use = "(blank)" and Zoning = " Eatonville". Existing use = "(blank)" and Zoning = " Roy". Existing use = "(blank)" and Zoning = " Urban Military Land". Existing use = "Other" and Zoning = " Eatonville". Existing use = "Public Facilities" and Zoning = " Eatonville". Existing use = "Public Facilities" and Zoning = " Roy". Existing use = "Quasi-Public Facilities" and Zoning = " Eatonville". Existing use = "Quasi-Public Facilities" and Zoning = " Roy". Existing use = "Transportation/Communication/Utilities" and Zoning = "(blank)". Existing use = "Transportation/Communication/Utilities" and Zoning = " Agricultural". Existing use = "Transportation/Communication/Utilities" and Zoning = " DuPont".

*Nisqually River Basin  
Level 1 Assessment*

Land use assigned	Includes areas where:
	<p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Eatonville".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Designated Forest Land".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Fort Lewis".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Moderate Density Single Family".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Rural Ten".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Rural Twenty".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Rural Five".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Rural Activity Center".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Rural Neighborhood Center".</p> <p>Existing use = "Transportation/Communication/Utilities" and Zoning = " Roy".</p>
<b>Unknown</b>	<p>Existing use = "(blank)" and Zoning = "(blank)".</p> <p>Existing use = "Vacant" and Zoning = "(blank)".</p> <p>All remaining area.</p>